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Application of Mobile Technologies through an Integrated Management System for Agricultural Production

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Abstract

The purpose of this study is to describe an application that analyzes all the possible tasks a farmer makes in the field, from ploughing the soil, fertilization and use of herbicides, up to traceability of the agriculture products. Farmers are provided with smart phones and tablets for documenting their tasks and products in real time, so that they can use the Integrated Management System in an optimal way, ensuring practical, financial and environmental benefits. The agricultural products will be documented safely and stored in a central information point for future traceability. These documentations may follow the product till the consumer so that he has all the production information available. To achieve these goals a mobile information system is developed that includes amongst others decision support capabilities for the farmer. The system also offers mobile services so as to support the implementation of a whole network of producing units.

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Keywords: AGRO 2.1/2.2; traceability; integrated management; smart phones; tablets; sensors

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1. Introduction

Information management is becoming an increasingly challenging task for farmers, especially in terms of the amount of data and the complexity of processes in integrated crop management cultivation. One of the most demanding functions is the acquisition of data and the traceability of agricultural products. Integrated crop management cultivation includes guidelines which farmers use to enforce actions for the production of safe agricultural products, with simultaneous respect to the environment [1, 4]. The paper focuses on the adoption of innovative agricultural technologies. These technologies may not be new as such, but novel to the farmer.

From the farmer's perspective, Rogers [5] identifies two characteristics of innovations that best explain different adoption rates, i.e. the perceived relative advantage of using the technology vis-à-vis the technology it supersedes, and its perceived compatibility with existing values, needs and experiences [5]. In addition, Rogers notes that innovations are more likely to be adopted if they are less complex, lend themselves to trialing and whose results are observable to others. Moreover, over the past two decades researchers have been increasingly recognizing the need to look at agricultural technologies as a package where farmers may adopt components at different times and speeds [3, 8, 10, 14].

The Greek national authority has published two models 'AGRO 2.1 Specifications' and 'AGRO 2.2 Requirements'. AGRO 2.1 constitutes the initial concepts for the certification of the integrated crop management cultivation that is applicable in every agricultural practice regardless of the type of crop. AGRO 2.2 describes the technical and legal requirements for the crop production system and accompanies the model of AGRO 2.1. It includes general rules and illustrates measures for environmentally friendly and good agricultural practice in order to produce safe and fine quality products, while achieving best environmental management [6].

The biophysical and agro-climatic environment can also be crucial for the success of new agricultural technologies, such as soil quality, water availability, topography, seasonal temperature changes or the presence of pests or diseases that could damage the crops [2].

One of the most dramatic changes in the use of mobile devices in agriculture is the development of monitoring protocols and systems for monitoring and managing farms and farm workers. The automatic monitoring of agriculture has dramatically risen with the recent deployment of wireless sensors and sensor networks. Many monitoring systems are end-to-end, tracking food production processes from initial seeding to delivery to the market [7].

The objective of this study is the description of an application of modern production management through an Integrated Management System for Agricultural Production. The application is being implemented with the exploitation of new and mobile technologies (apps for smart phones and tablets). Production and certification of selected agricultural products follows Integrated Management Systems in the Agricultural Sector (AGRO 2-1 & AGRO 2-2). The Integrated Management System theoretically supports Precision Agriculture as it provides a basis for qualitative evaluation of the agricultural production which also affects the criteria and the specifications of Precision Agriculture [13]. It is relevant with the requirements and systems used in Precision Agriculture for the GPS/GIS systems as tools to support quality ensured agricultural production [11]. While GIS technology will offer tremendous capabilities for more informed Agriculture Management decision making, rendering competent decisions will still depend on having reliable data. Towards this goal the proposed system provides a wide range of services to assure quality during production.

2. Overall Systems Architecture

2.1. Objectives

Agricultural production should always be based on three main axioms: *Product Quality - Consumer's Safety - Environmental Friendly*. Towards these goals, the Integrated Management of agricultural production is a necessity. The proposed advanced information system aims at:

1) Supporting the workflows of an Integrated Management System for agricultural production which leads to certified agricultural products based on the national standards AGRO (2-1 / 2-2) and ISO 9000/2000.

2) Providing online mobile services to the farmer so as to be able to:

Review and analyze all the possible and proposed agricultural tasks which could be fulfilled in the field, as well as all the plant fertilizers and pesticides which are necessary for proper cultivation for a plant growing season in crop and based on the cultivation history as a whole.

Progress with cultivation and production. The farmer will be provided with electronic means for documenting each product through several mobile services in real time, so the farmer will be able to apply in an optimized way the Integrated Management System,

Each product will be documented safely and stored in a central information point where future traceability will be reassured. These documentations may follow the product till the end user (the consumer) and the consumer will have the necessary production information available.

To achieve these goals the development of an advanced mobile information system is proposed. The system will include amongst others decision support capabilities for the producer so as the Integrated Management to be achieved. The system will also offer mobile services so as to support the implementation of a whole network of producing units.

2.2. Architecture

The architecture's main ontologies are:

- **The Advanced Mobile Information System:** The overall system includes the necessary software and hardware solutions to provide full and efficient online and mobile services to the farmers and agronomists. Specifically the main modules of the system are:
- **The Agricultural Database Server:** The repository of agricultural data focusing on efficient production based on AGRO (2-1, 2-2) and ISO 9000/2000 quality standards. The database preserves on the long term all the necessary data, information, criteria, images which will lead to a high quality standard agricultural production. The data are enriched constantly as the plant growing season and production are in process. The field experts are defining which are the necessary data and data types to be stored.
- **The Traceability Database Server:** The repository of relevant data which lead to successful tracing of the product after the production and while it is being transferred and transacted. Information regarding the location of the product and environmental data throughout the whole process are stored for each product. The database has the ability to uniquely identify each product and trace it throughout its life cycle.
- **The Decision Support System:** The DSS is using data from the Agricultural Database Server and combines it with certain environmental and meteorological data so as to produce useful recommendations regarding the necessary steps towards a high quality production. The DSS also produces alarms in cases of bad weather conditions or other circumstances which might harm the production process. The recommendations / alarms are being presented to the farmers so as to support him to decide and take the necessary steps to protect the production.
- **The Web and Mobile Server:** The server allows uninterrupted communication through land and mobile networks and exchange of data between all the modules of the architecture. It is the gateway of the information system to its key users (the farmers and agronomists).

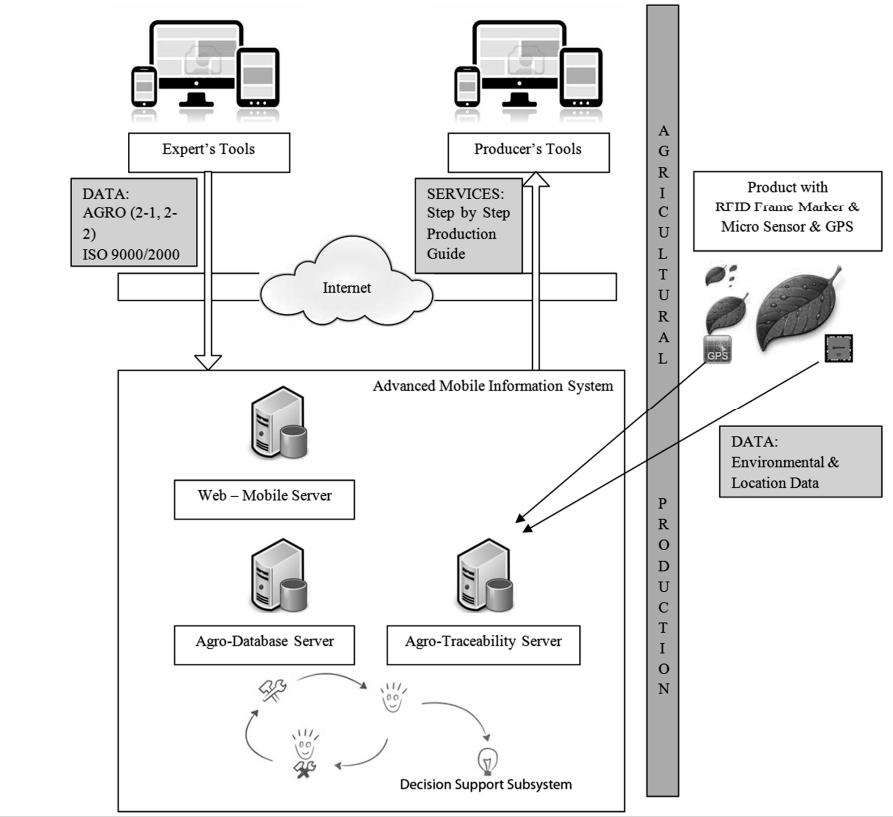

Fig. 1. System's Architecture.

The Expert's Tools: Are software tools and usable user interfaces as well as dedicated mobile applications which allow the expert to capture, disseminate and store crucial agricultural data to the agricultural database server. The expert is able using his desktop / laptop / tablet/ smart phone to gather and send data to the main information system so as to be managed and stored in the long term.

The Farmer's Tools: Are software tools and usable user interfaces as well as dedicated mobile applications which support him throughout the production process. The main tools is a step by step for achieving quality standards during the production process, alarms regarding weather conditions or other factors which might harm the production and relevant information. The aim is the farmer to have in his hand and in the field a useful tool to plan, manage and protect his production.

The Product: The product is the result of the production process, packaged and ready to be transferred to its final destination. The product apart from the agricultural good is being protected by a frame marker which identifies uniquely the product and with a use of a tablet / smart phone a reseller, customer can be informed of when and where it was produced, the places it was transferred and stored etc. In addition the frame marker is used as a standard RFID solution using only smartphones rather than barcode readers so as to be used during transfer, storage and transaction. In addition the product is being protected by a micro sensor and micro GPS receiver which in combination gather environmental (e.g. temperature and / or humidity etc.) and location data which are being transmitted to the traceability database. The target is the information system to store and manage information regarding where the product was transferred and under what conditions so as to ensure quality and traceability after production.

The data exchanged and main services provided by the architecture include:

- Expert's Data: the data gathered and transferred from the expert's tools and devices to the advanced mobile information system

- Step by Step guide to the farmer: Data regarding the next step towards an efficient and quality production.
- Sensor and GPS Data: Environmental and location based data from the micro sensors and GPS receivers to the traceability database server.
- Frame Marker Data: A marker to facilitate RFID for the products and redirect a smartphones web explorer to information regarding where, when and how the product was produced and stored.
- The communication protocols are being used so as to ensure data exchange between the distinct parts of the system are the following:
- Data are exchanged with the use of OAI-PMH protocol between the main databases between the servers (DSS-Server, Web-Mobile-server, Agro-traceability) and the applications of the Expert and the Producer.
- GIS data are exchanged through wireless data network protocols.

2.3. Technologies Used

The technologies used for the implementation of the system are the following:

Focusing on the Integrated Management System for production support:

- Agricultural Databases to collect and manage crucial data regarding AGRO (2-1, 2-2) and ISO 9000/2000 quality standards for the production.
- Mobile Networks for all devices used, 3G and 4G broadband mobile internet.
- Development of Mobile Applications in Apple iOS, Google's Android and Windows 8 for the Expert's and Producer tools.
- Development for Web Application and services for data exchange of the Expert's and Producer tools.
- Web GIS Systems for the GPS information and its presentation on maps and chartographic systems.
- Decision Support Systems. Neural networks and Artificial Intelligence algorithms to recommend decisions and produce alarms.

Focusing on Traceability of agricultural products

- Traceability Databases to collect and manage the necessary information to trace a product.
- RFID tagging with frame markers to redirect smartphone web browsers regarding information on the product and / or store new information to the traceability database.
- Micro sensors and Micro GPS receivers for gathering and transmitting environmental and location data.
- Sensor Networks so as data to be exchanged from the sensors and receivers to the databases and vice versa.
- The user interfaces and tools for the Expert and the Producer are currently under development. The development principles are based on modern usability and accessibility guidelines [9, 12].

3. Conclusions

Development plans for an Integrated Management System for agriculture production with the adoption of mobile technologies in order to implement a systematic and scientific traceability of the agriculture products.

- Presentation of the system's architecture.
- Detailed description of the expert's and farmer's tools.
- Documentation of all the technologies for the integrated management of the products. This proposed system provides environmental monitoring and traceability management for farmers.
- Step-by-step guide to the farmer.
- Application of the proposed system in various agricultural environments.

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